2020-02-07

Collaborative and Inclusive Process with the Autism Community: A Case Study in Colombia About Social Robot Design

Ramirez-Duque, AA

http://hdl.handle.net/10026.1/15925

10.1007/s12369-020-00627-y
International Journal of Social Robotics
Springer Science and Business Media LLC

International Journal of Social Robotics
https://doi.org/10.1007/s12369-020-00627-y

Collaborative and Inclusive Process with the Autism Community: A Case Study in Colombia About Social Robot Design

Andrés A. Ramírez-Duque[1,6] · Luis F. Aycardi[2] · Adriana Villa[3] · Marcela Munera[2] · Teodiano Bastos[1] · Tony Belpaeme[4,5] · Anselmo Frizera-Neto[1] · Carlos A. Cifuentes[2]

Accepted: 18 January 2020

Abstract

One of the most promising areas in which social assistive robotics has been introduced is therapeutic intervention for children with autism spectrum disorders (CwASD). Even though there are promising results in therapeutic contexts, there is a lack of guidelines on how to select the appropriate robot and how to design and implement the child–robot interaction. The use of participatory design (PD) methods in the design of technology-based processes for CwASD is a recognition of the stakeholders as "experts" in their fields. This work explores the benefits brought by the use of PD methods in the design of a social robot, with a specific focus on their use in autism spectrum disorders therapies on the Colombian autism community. Based on what proved to be effective in our previous research, we implemented participatory methods for both the CwASD and the stakeholders. The process leverages the active role of participants using a focus group approach with parents and specialists, and scene cards, narrative and handmade generative methods with the children. To overcome some challenges of traditional PD processes, where not all community actors are considered, we included a Colombian community consisting of therapists, nurses, caregivers and parents. The proposed PD process provides an opportunity to learn from several community actors (and thus different cultural and social aspects of developing countries), improving traditional robot design methods. In this way, the findings are summarized through a set of guidelines regarding the design of a social robot-device suitable to be implemented for robot-assisted therapy for CwASD.

Keywords Autism spectrum disorder (ASD) · Child–robot interaction (CRI) · Participatory design (PD) · Social assistive robotics (SAR)

1 Introduction

Social assistive robotics (SAR) is an established research area in robotics in which robots are used to support patients during a range of therapeutic and healthcare interventions [3,29,31]. Promising results exist in therapeutic interventions for children, elderly, stroke patients, and special-needs populations [26]. The introduction of social robotics in real-world healthcare practice is proof of a change in people's attitudes towards the application of robotics in general and Human–Robot Interaction (HRI) in specific.

One of the most valuable contributions of SAR has been the support for Autism Spectrum Disorder (ASD) therapies. ASD is a neuro-developmental disorder that affects people, often from birth, and for which symptoms are often found in early years. ASD is characterized by impairments in verbal and non-verbal social communication, restrictive interests and atypical behavior [1]. Children with ASD have difficulties with attention and concentration, recognition of emotions, and sometimes present repetitive or aggressive behaviors [9]. In Colombia, the Colombian League of Autism estimates that 1 in 110 children are diagnosed with ASD, with incidence in other nations often being higher, such as in USA, where the rate is 1 in 59 children [2].

✉ Andrés A. Ramírez-Duque
aaramirezd@gmail.com

1 Federal University of Espirito Santo, Vitoria, Brazil

2 Colombian School of Engineering Julio Garavito, Bogotá, Colombia

3 Tejido de Sueños, Medellín, Colombia

4 Plymouth University, Plymouth, UK

5 Ghent University, Ghent, Belgium

6 Department of Bioengineering, Faculty of Engineering, Universidad El Bosque, Bogotá, Colombia

Published online: 07 February 2020

In the context of ASD therapy, SAR has been used to assist the diagnostic process, and also to practice social skills [6]. Skills such as making eye contact and recognising emotions [32], joint attention [21,28], increasing self-initiated interactions [8], and sharing in simple activities, with the aim of encouraging basic verbal and non-verbal communication [20]. Even though the evidence for the efficacy of SAR for ASD therapy is mounting [7,10,29], there is still a lack of consensus on how the interactions should be addressed and which robot morphology might be most effective. Most robots used with ASD populations are off-the-shelf robots, from toy robots to social robots, which were not specifically designed for the ASD population or for therapeutic ASD interventions [31]. We believe there is room for improvement here and propose a participatory design process to arrive at a robot design and interaction which is tailored towards the population of children with ASD [14].

Several design techniques have been explored over the years, which all integrate contributions from different populations affected by the design decisions (e.g., stakeholders community) [11]. The participatory design (PD) process is a well-known strategy in industrial design and the arts to develop products and services for a target population. The philosophy behind PD is to empower the people that are involved in a specific activity or situation by providing them space and a voice so that all can contribute in the decision making [13]. The intention of the process is to, in the end, achieve products or services that represent the real needs, desires, and expectations of the users, designers, and stakeholders. During the last decade, the effectiveness of designs based on participatory practices has stirred the interest of researchers in different fields. The application of PD techniques is particularly promising when transferring knowledge and systems from research to the real-world, especially if the success of the product or service hinges on the interaction with the human.

The use of PD methods in the design of technology-based processes for health care is a recognition of the stakeholders as "experts" in their fields, highlighting the different experiences and attitudes that they may have [11]. In this sense, all the actors in the project are recognized as valuable contributors, which plays a crucial role in ethical, political and social considerations of the development. The target populations and their environment (families, society, groups of allies and friends) are no longer seen as a source to obtain information and requirements to produce results, but rather a partner with experience and a different way to see the world that can be a part of the solution [23].

PD has been used in the design of SAR for ASD [17] and development of HRI in the healthcare systems [31]. However, implementing a participatory or co-design process with ASD populations can be very challenging. Researchers and designers need to find ways and techniques to overcome several limitations of traditional co-creation methods as they have to establish additional *modus operandi* to choose and adapt co-design techniques based on their participants' abilities (i.e., their strengths and skills) rather than their disabilities.

Despite that in recent years PD methods have been adopted to develop interventions for populations with special needs. The implementation is often limited to a few aspects, and only a few of the user's and stakeholders' contributions influence the final decisions. Additionally, the design of SAR for ASD is an extensive process and, despite the presence of exploratory work in the field, many questions remain unanswered. In this work the authors report the development of a PD methodology that aims to identify guidelines for the design of a social robotic device to be implemented in a robot-assisted therapy for children with ASD. PD is inherently reliant on the culture and context of the location in which it takes place, and in this context, we believe that PD also represents an opportunity of gathering culture-specific findings and making cross-cultural observations. Our case study is situated in a Colombian context and the main contributions of this work are: (1) a novel 2-years long participatory design strategy based on well-established generative methods that take into account the experiences and views of both stakeholders and children; (2) a case study reporting on the Colombian context and Colombian robot-based intervention preferences. To the best of our knowledge, there are no previous reports of PD implementation within a Colombian autism community.

This work is organized as follows: a brief background regarding the project and the techniques is presented in Sect. 2; the methods and details about the design are explained in Sect. 3; the results of the case of study is illustrated in Sect. 4; finally we close with a discussion and conclusions.

2 Background

The Compliant Soft Robotics (CASTOR) project aims to develop a compliant, soft robot, to be integrated in next generation ASD rehabilitation scenarios based on tangible and affordable SAR. This project has a special relevance regarding the social context of developing countries.

To develop a PD method for SAR and ASD therapies, we briefly review recent PD techniques used in healthcare. From the existing procedures, a list of elements that could be incorporated into a PD method for the community around the ASD was selected. The authors selected PD features that empower children and adults with ASD, as well as their parents, teachers, and caregivers. Also, an increasing awareness has been placed on the importance of involving the community in the design process to better understand their wishes, concerns, needs, and preferences. There are a range of research projects, each using different methods. In these the main objective was to design technological tools as learning applications [12], serious games [4,22], interactive environments [23] and robotic-devices [5,18,31,33]. Regarding the participatory methods used, most of the projects implemented activities that allowed the children and stakeholders to participate in different roles, engaging as users, testers, informants, and designer, thereby increasing their motivation and their ownership of the project.

In general, the two first roles—users and testers—were the most commonly used, even though they are considered to allow only "passive participation". The information most often was obtained through questionnaires and interviews with parents and teachers, and sometimes through using observations of the children's behavior before and after using the designed object [23]. In other cases, parents and clinicians were involved both as informants and designers, allowing more participatory and deciding roles. For example (1) for the design the intervention protocol in a particular school for children with ASD using the robot seal Paro [5]; (2) the design of a robot-based environment to support the therapy for severe CwASD [33]; (3) the definition of the role and some aesthetic features of the Kaspar robot to interact with CwASD [16,17]. On the other hand, a remarkable effort was by Huijnen et al. [18] consolidated and proposed a list of the main domains and objectives where SAR could be implemented in a CRI to strengthen ASD therapies. In this case, the approach was performed through the involvement of focus groups.

The active participation of children, while often straightforward, can become challenging when the children have special needs. However, different participatory methods which involve children have been reported [15]. A common strategy was based on providing narrative structures to develop a story, stimulating curiosity and inviting and encouraging children to contribute. For example, Frauenberg et al. [12] provided high-functioning CwASD with a story based on a comic strip. The authors gave them the start and end points of the comic and asked the children to incorporate a particular object available during the activity [12]. Malinverni et al. [22] used scene cards to guide a narrative task and relied on drawing activities to develop video-game characters. Benton et al. [4] used a generation process based on a visual template, using physically drawing and art materials to allow CwASD to design a math-based computer game. Finally, Vallès-Peris et al. [31] used narrative-based participatory methods using free drawing activities, modeling paste and construction blocks sessions to analyze the children's view of HRI in health care.

In this work, the goal was to explore the benefits brought by the use of PD methods in the design of a social robot, with a specific focus on their use in ASD therapies. Based on what proved to be effective in earlier work, we implemented participatory methods for both the CwASD and the stakeholders. The process used a focus group approach with parents and therapist, and used scene cards, narrative and handmade generative methods with the children.

3 Methods

Implementing PD is not just a methodology to improve and enhance a product's final design, but also an opportunity to understand and gain knowledge about the community's context, and to build trust and confidence between researchers and the community. It is also a chance, in this case, to show the benefits of technological tools in this complex social context. Thus, the participatory process was made up of different stages that could lead us to achieve the following objectives:

- Obtain contextual information that allows the establishment of the needs, interests, preferences, fears, desires and priorities related to functionality of the robot and its use as a tool in ASD therapies.
- Validate the insights gained through the literature review for the design of the robotic device.
- Generate ideas and creative solutions through reflecting on our experiences.
- Promote the take-up of our research process and its results.

The process for designing a compliant social robot appropriate to be used in ASD therapies with children was planned together an interdisciplinary team. The CASTOR team included the creative enterprise specialized in inclusiveness design "Tejido de Sueños",[1] a Howard Gardner Clinic group composed of healthcare and administrative specialists and an engineering group. According to the agreements reached in the work sessions of the CASTOR team, the participatory process was established as a 2 year-long project. The first year was planned into four phases: (1) sensitization; (2) focus group with stakeholders; (3) generative intervention with children; (4) validation and ratification of the preliminary findings. The implementation scheme for the first year is illustrated in Fig. 1. For the second year, four more stages were planned: (5) perceptual maps and conceptual design; (6) preliminary 2D/3D prototyping with community feedback; (7) detailed design and manufacturing, (8) presentation and validation of results. Also, as a main participatory activity with children, a narrative strip based on storytelling activity to select and validate robot 2D/3D sketches will be implemented. A summary of all CASTOR's phases with the objectives in each stage and the proposed activities is schematized in Table 1. The focus of this work is to report the findings

[1] Design company for inclusion: https://www.tejidodesuenos.com/la-empresa.

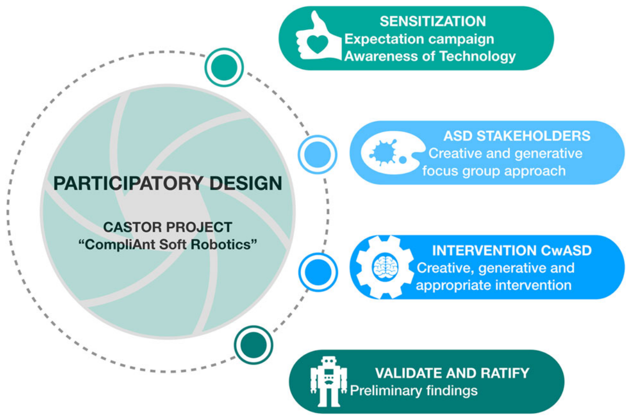

Fig. 1 General scheme of the participatory design (PD) in the first year

of the first year of the CASTOR project. Therefore, a detailed description of the methodology and main results of the first four phases is described below.

3.1 Sensitization

The sensitization phase aimed at introducing the context, the objectives and the team of the CASTOR project to the local ASD community. Likewise, the sensitization phase allowed the CASTOR team to learn about ASD and interventions, the personal experiences of parents and specialists, in addition to the needs and concerns of the ASD community. This phase comprised two steps. The first one consisted of an expectations campaign, in which we talked about the project over several visits to the clinic. Throughout this time several activities were carried out to query parents and stakeholders about their views and ideas on and about robotics. Initially, a drawing of a robot was displayed in the facilities of the clinic along with a mailbox with three questions. The first question asked stakeholders to describe how they imagine a robotic device. The second question enquired about how robots could assist in therapies. The third question asked the stakeholders about how they imagined a robot to benefit CwASD. Over those 2 weeks we organised several robot demonstrations and showed videos about different types of robots. Finally, the expectation campaign was closed by a formal presentation about the 2-years CASTOR project.

3.2 Focus Group with Stakeholders

The focus group phase first served to build a common ground between researchers and the community, and allowed the sharing of experiences and views about the role of each of the actors involved in the process. In this phase four activities were implemented, context mapping, CRI idealization, creative robot design and intervention prioritization (see Fig. 2). The first activity relied on a form which was sent out before the session to parents and therapist in order to do a customized context mapping. In the form, some personal aspects and expectations about the activity were asked, and four questions were included to inquire about the needs and opportunities to improve ASD therapies as well as to identify current and future interests, wishes and concerns regarding the use of a robot to assist specialists during therapy. The four questions are described as follow:

1. What are the positive and negative aspects of current ASD therapies?
2. If you could create a magic tool to help therapy, what would this tool be?
3. Imagine a therapy with robots, what would be the best and the worst aspects?
4. Imagine that you have used the therapies with robots for more than 10 years. In this case, which is the best or the worst thing that has happened to you so far?

The participants had small-group discussions about their opinions on all four questions. Then, in the second step, a member of the CASTOR team who acted as moderator asked the participants to imagine the ideal robot intervention and describe this through a collage. The moderator invited the participants to include emotional aspects, actions and impressions. The session ended with a plenary discussion, giving each participant the opportunity to express their views to the others.

The main generative step was implemented as an unconstrained creativity activity using recycled materials. The participants were placed in small groups and requested to create a robot. A final plenary discussion served to formulate guidelines for researchers and designers.

Finally, the prioritization domain activity closed the focus group session. This last activity aimed to elicit the five most essential domains or objectives for robot-assisted therapy for CwASD. The objectives and domains used correspond to those identified by Huijnen et al. [17].

3.3 Generative Task Developed for CwASD

The aim of this phase was to provide CwASD the opportunity to actively participate in the decisions that affect them. With that idea, four simple generative activities were designed considering the condition of the participants (see Fig. 3). A set of six cards of the same size were prepared with references/images of robots commonly used in ASD therapies. In order to avoid aesthetic bias, the robot cards were selected as follow: (a) two anthropomorphic robots; Kaspar [25] and Nao [3]; (b) two biomimetic robots; Probo [27] and Pleo [19] and (c) two non-biomimetic robots; Leka[2] and Romibo [30].

[2] https://leka.io/en/index.html

Table 1 Summary description of the 2 year-long participatory process for the design a social robot with the participation of autism community

Year	Phases in the participatory design	Objectives to be reached	Activities to perform with: Children	Activities to perform with: Parents and therapist
2	(1) Sensitization	Introduce the context, the objectives and the team of the CASTOR project in the ASD community as well as identify the potential areas for robot intervention and motivate the community to participate in the participatory process	Workshop session	Workshop session
			Robot intervention demonstration	Robot intervention demonstration
				Information support regarding CASTOR project
1	(2) Focus group with stakeholders	Inquire about the needs and opportunities to improve ASD therapies	Creative robot design using recycled materials, free play and dancing	Therapy context mapping
		Identify interests, wishes, and fears regarding the use of a robot to assist the specialists in therapy processes		CRI Idealization
		Generate ideas and proposals for the robot design and the potential benefits to ASD therapies through the use of a robotic-device		Creative robot design
				Domain intervention prioritization
1	(3) Generative intervention with children	Identify how the robot's physical features and interaction interfaces influence the perception of CwASD	Sorting cards	NA
		Identify the children's preferences for different morphological characteristics of the robot	Adjectives matching	
		Explore the thoughts and preferences of children about the design of a robot based on didactic exercises	Morphological variants	
			Design my robot friend	

Table 1 continued

Year	Phases in the participatory design	Objectives to be reached	Activities to perform with: Children	Activities to perform with: Parents and therapist
1	(4) Validation and ratification of the preliminary findings	Validate and ratify preliminary design decisions and plausible intervention domains for SAR	NA	Personal interview
		Collect additional information about the acceptability of the developed activities		Online questionnaire
2	(5) Perceptual maps and conceptual design	Establish design requirements and conduct requirements analysis based on collected evidence through primary and secondary source		Activity to be developed by the CASTOR members
2	(6) Preliminary 2D/3D prototyping with community feedback	Propose many sketches, diagrams and prototypes of the proposed robot to be tested with different actors	Storytelling based on proposed sketches	Workshop: iterative validation of prototypes' feature and final decisions regarding the robot design
			Drawing activities: child's imaginary and prototypes idealization	
2	(7) Detailed design and manufacturing	Choose materials, sensors, passive and active elements, detail dimensions, assemblies, interfaces	Robot-mediated intervention demonstration in laboratory setup using the final prototype	NA
		Build the robotic-device based on the community's preferences and needs		
2	(8) Results: presentation and validation	Present the project's outcome and validate the robot through the use in robot-assisted therapy based on the community's demand for CwASD in the HG clinic	Implementation of a well-established protocol for robot intervention in clinic-setup	Workshop: CASTOR's outcome analysis and feedback throughout two-long years process

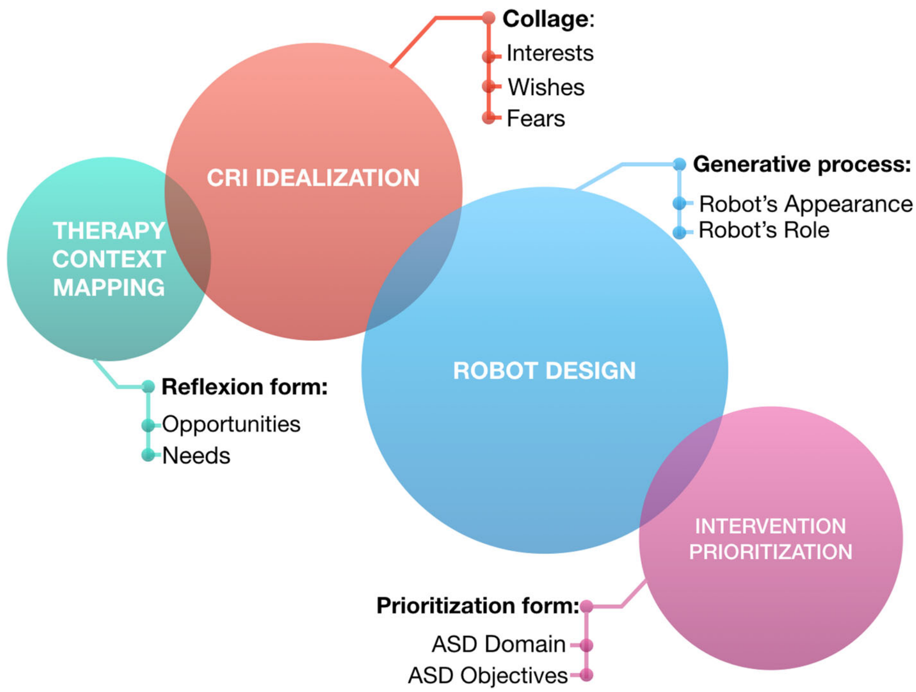

Fig. 2 Diagram of focus group developed with parents and therapist

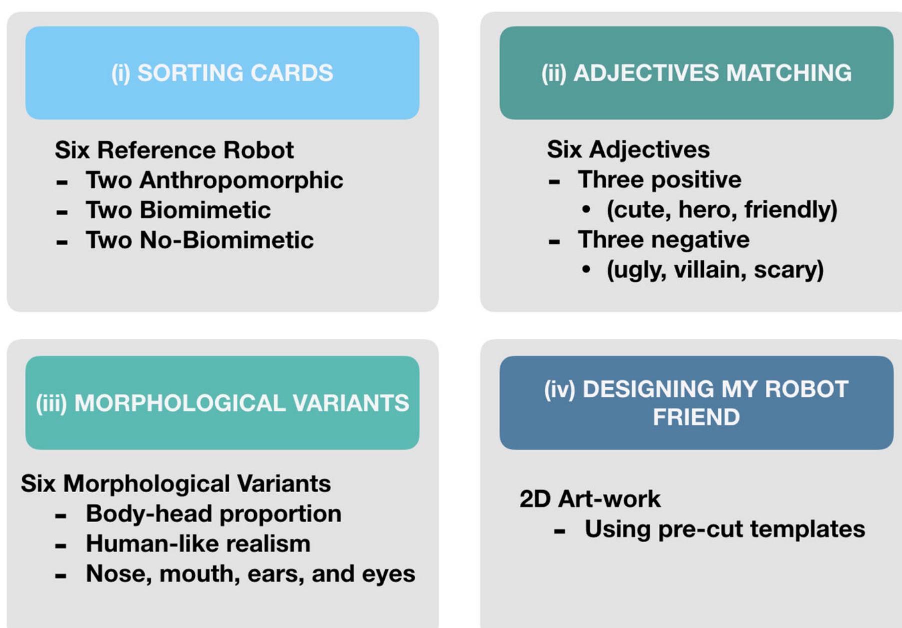

Fig. 3 Scheme of the generative task developed for CwASD

In the first stage, all six cards are placed on a table in front of the child. After telling a short story about all the robots, the therapist asks the child to take the card that she likes the most. Once the child chooses a robot, the corresponding card is removed while the other cards are kept on the table. The therapist continues asking the child robot she likes most, and the sequences is repeated until all robots are ranked. In the second stage, the cards are again placed in front of the child, and another set of cards depicting different adjectives are laid out as well. The second set of cards shows six adjectives by using the following emoticons/pictographs: *cute, ugly, hero, villain, friendly and scary*. The therapist invites the child to match each robot with an adjective, this allows the therapist to see which associations or feelings the child has for each robot. During the third stage, the therapist presents the child with a third set of cards with aesthetic modifications of three robots. This serves to learn the child's preference for specific robot features. For each robot category (anthropomorphic,

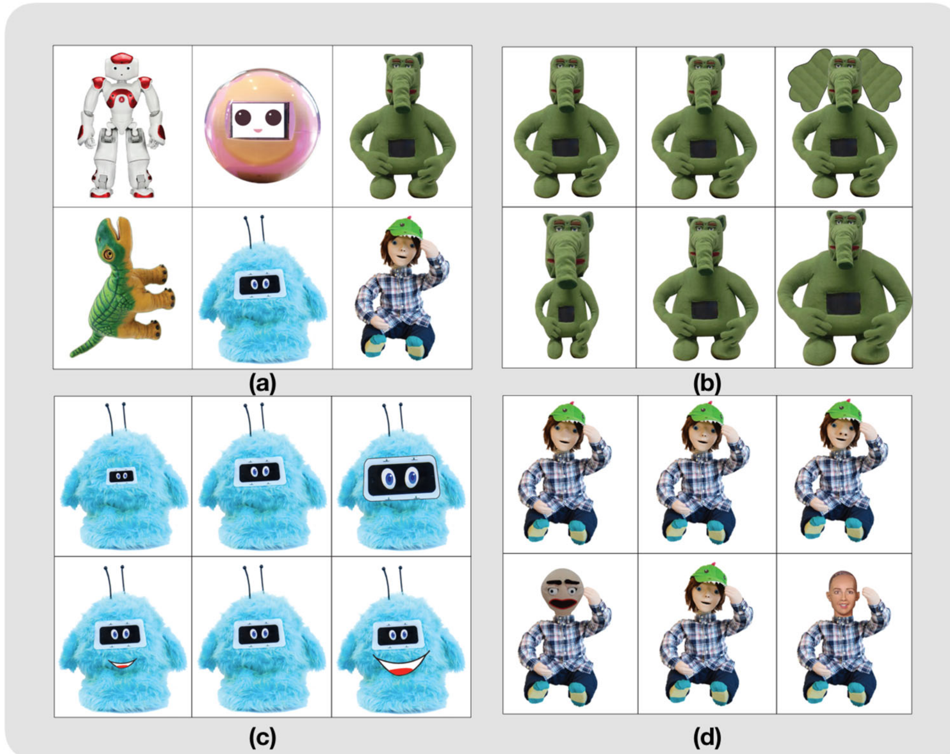

Fig. 4 **a** Set of cards with six robots commonly used in ASD therapies; **b** aesthetic modification of the robots Probo; **c** Romibo and **d** Kaspar

biomimetic, non-biomimetic) we chose a robot where particular aesthetic or physical traits were more prominent. In this way, Probo's image was chosen to modify the size of the ears and the body-head proportion. Romibo's image was chosen to show the modification of mouth and eye size. Kaspar was chosen to modify the human-likeness and the nose size (see Fig. 4). In the fourth and final stage, the therapist asks the child to make a collage of their robot by choosing different pre-cut templates of heads, bodies, eyes, mouths, and noses, representing different morphological characteristics. At the same time the therapist encourages the child to comment on their decisions while building the robot. This activity is also used as an incentive for their participation, as the children can keep the art work if they so wish.

3.4 Validation and Ratification of the Preliminary Findings

We also designed a questionnaire for the ASD community to confirm and validate the findings of the previous phases. The questionnaire was distributed in the Howard Gardner clinic and through social networks to other Colombian institutions specialized in the treatment and development of ASD therapies. It consisted of nine items related to the robot's physical features, 17 items related to the robot's physical behavior, one item about the use of sensory elements, six open questions about the role of the robot in the intervention and nine more general questions.

4 Results

The data generated during each phase of the participatory process were analysed. For this we observed video recordings allowing the team to understand the activity's atmosphere and identify the main aspects. The stories, attitudes, and opinions that appear repeatedly, the surprise comments, the novel concepts that were uncovered, and the positive or negative responses of the participants were noted. Four members of the research team independently transcribed the recording, taking into account the primary purpose of the activity. The individual results were discussed, and a final summary was generated to gather the most important findings.

4.1 Sensitization

The sensitization phase took place in the two HG headquarters, one week was spent in the first headquarter, followed by a second week in the second headquarter. We placed the robot art work and the mailbox near the clinic's lobby, so children and stakeholders would engage. Additionally, during the sensitization process, a member of the CASTOR team invited the therapists, parents and caregivers that were in the clinic to participate in the official workshop introduction and the focus group activities. CASTOR members spent a considerable amount of time promoting the workshop.

In this phase, 18 stakeholders responded to three questions posted by the mailbox. Regarding the first question 61% of the respondents associated words such as *apparatus*, *machine* and *tool* to describe the robot. The other 39% of the participants assigned to the robot abilities to perform automated functions, in addition to artificial reasoning. In the second question, 17 participants answered that they believed that the robot could be suitable and very useful to help CwASD, and only one person answered that he/she did not know about the subject. Finally, regarding the third question the most used phrases to describe the possible benefits of using robots in therapy were to *help them communicate*, *keep them motivated in therapy* and *teach them to play*.

Three CwASD, eight parents and four therapists actively participated in the workshop. During this activity the participants expressed their interest to participate in the whole process and highlighted the importance of carrying out this type of activities together with the community.

4.2 Focus Group

In the HG Clinic four focus group were set up, two for parents and two for specialists (therapists and caregivers). In each group, the same four stages were used, but adapted to consider the relationship the participants had to CwASD. The focus groups were organized in the clinic's facilities taking into account the stakeholders' availability. A total of 14 parents (N = 14, all female, no age data available) and 16 specialists (N = 16, two male and 14 female, average age, 24 years) of the HG Clinic participated in the design process. The specialists had worked for at least 2 years with children with a variety of impairments, including ASD, intellectual disabilities, learning problems, and cerebral palsy. Both parents and specialists reported no previous experiences with any robot or related robotic-based activities.

According to what stakeholders expressed in the focus group, three main issues of including robots in ASD therapies are summarized as main negative aspects: adverse emotional reactions of the child, negative conditioning of the child's behavior and loss of human touch in the therapies. However, many positive aspects were also identified. For example, both parents and specialists agreed that through robot-assisted therapy they would wish to increase the child's motivation, reduce the child's anxiety, improve the understanding of the child's emotion, and enhance the child's confidence in therapy. The findings of these aspects will be extended in the discussion section.

In the generative activity, all participants described a robotic device that could be composed of colored lights, different textures and materials, have buttons and a screen, have clothes as well as a face, upper limbs, microphone and speakers to communicate and interact with the child. Regarding the size, the participants expressed that it would be desirable that the robot's eyes are located at the same height as the child's to facilitate the interaction. In addition, they think that the materials and structured used in the robotic devices should allow physical contact, such as hugging and shaking hands

4.3 Generative Task with CwASD

The activity designed for the children was run by a psychologist at the HG clinic. A total of 11 CwASD (three female and eight male) with ages between 3 and 9 years (5.81 ± 2.08) participated in the activity during their psychology sessions. The event took a maximum of 20 min.

Throughout the activity, the CwASD exhibited varied preferences regarding the robot's appearance; however, some agreement emerged. For example, in the card sorting activity, nine children chose the Pleo card within the first three positions, followed by Probo and Romibo cards, which were selected six times within the first three positions. In contrast, the Nao card was chosen eight times within the lasts three positions, followed by Kaspar, which was chosen seven times.

A similar pattern was evident in the adjective matching activities, in which 82% of children assigned positive adjectives to Pleo, and 73% matched negative adjectives to Kaspar and Nao. In summary, four children assigned the hero adjective to Pleo while four other children described it as friendly. Romibo, with four votes, was chosen as the cutest, followed by Leka, with three votes. Four children assigned the ugly label for Probo, making him the ugliest. Regarding the villain adjective, Nao and Kaspar obtained the maximum score, with three votes each. Kaspar was also chosen as the scariest with three votes. A summary of the results is shown in Fig. 5.

A general analysis of the last activity showed that the 11 children had preferences for exaggerated facial traits, such as a large mouth, ears, and nose as well as large and expressive eyes. Finally, in the generative activity, five children chose a dragon body, and animal-like heads for the robot; four chose a robotic body with a biomimetic head (two animal heads and two human heads), and two picked a human body with a robotic head. All the children showed motivation during the creative activity; some of them showed an increase in communication using words and non-verbal signs to express enthusiasm regarding their final sketch.

4.4 Validation and Ratification of the Preliminary Findings

A questionnaire used to confirm (or reject) our preliminary findings was distributed to parents and therapists in the HG Clinic. Direct interviews with members of the CASTOR team were also used. In total 30 stakeholders (14 relatives of CwASD and 16 specialists) participated in this last stage.

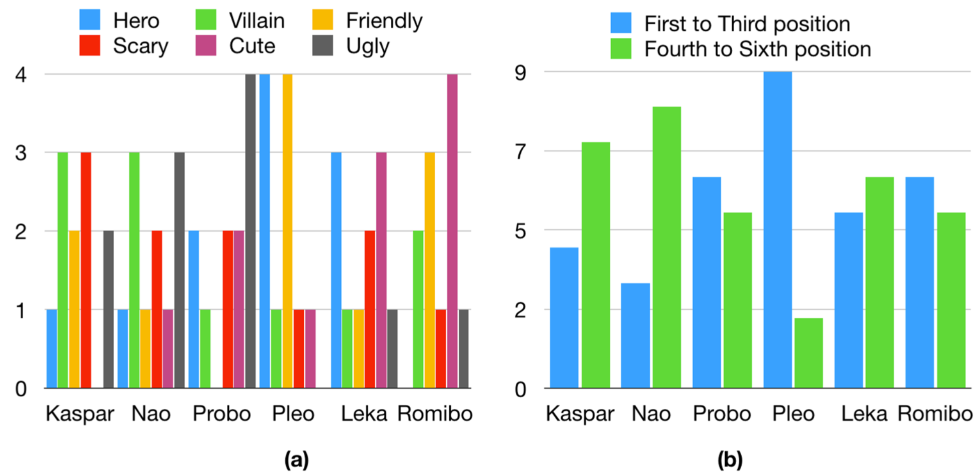

Fig. 5 Graphical representation of the results in the **a** adjectives matching; and **b** sorting card activities

The results showed a preference for the use of modular parts, plastic materials and textile, and a soft body. The participants believed that acoustic functions, movement of arms and facial expressions (mouth, eyes, and eyebrow movements) are essential for the CRI scenarios. Additionally, 97% of the surveyed agreed with the following expression; "it should be possible to add items, such as clothes and accessories to customize the robot," and 93 % of the participants agreed with the statement that "the robot must be composed of a head, trunk, arms, and legs". Regarding the statement "the robot's facial expression must be similar to human facial expressions", 90% of surveyed agreed, and with the sentence "the robot's eyes should be at the same height as the child's eyes", 87% of the respondents supported this. The participants were asked about the robot's appearance, 50% agreed that "the robots must look like a fantastic character", while 40% expressed neither agreement nor disagreement.

5 Discussion

Through the implementation of the first four phases of the PD process, a relationship of trust and understanding was established between the parents, therapists and researchers. This was essential in this first steps of the CASTOR project, in order to balance the power distribution between the different actors and to assure a productive process. It is important to highlight the relevance that this aspect has for the later stages of the process. At the beginning of the CASTOR project, when we were looking for a collaborative partnerships, the first responses by the health care staff included sentences like *We are not willing to participate because researchers always use us to collect data and never come back; this is something that therapists and parents do not like*.

Thus, through our collaborative and inclusive approach, the project has emphasized the necessity of prioritizing the people's well-being and the community awareness rather than the technology results of this type of participatory process. The activities implemented also became an opportunity to spend time with other partners in a new context that could hold all of the people involved. In Fig. 6, four pictures of the developed activities with parents and therapist are presented.

5.1 Awareness of CASTOR Project in the Sensitization Phase

In the sensitization phase, the parents and therapists had the opportunity to know and understand the purpose of the CASTOR project, learning about the evidence gathered in other countries and regions about the potential benefit of the robot-assisted intervention. Through our expectation management campaign, a positive environment was created and, for this reason, all participants were more open to participate in the creative and generative activities. Furthermore, the participation and positive attitude towards the project contributed to the building of an enjoyable and collaborative atmosphere between the volunteers and the CASTOR team. As the participants progressed between the activities and phases, both parents and therapist felt uninhibited to express their opinions and creative ideas, positively enriching the outcome of the process.

Despite the weak influence of robotic-based technology in a low-income country such as Colombia, the findings of the expectation campaign showed that the participants appear to be in favor of the use of robots within the therapies. In addition, we showed that stakeholders do have conceptual ideas regarding the proposed technology.

5.2 Findings from and Reflections on Focus Group Discussions

Throughout the four groups, many interesting opinions and ideas were generated, but only the commonly agreed upon ideas are described below:

Fig. 6 Activities developed in the four focus group (two for parents and two for therapists)

Concerning the current needs of autism spectrum therapy, stakeholders expressed that it is necessary to modulate the child's behavior before a therapy session. The route from their houses to the clinic or an external event before coming to the clinic can alter the child's behavior and thus waste the therapy time due to, for example, anxiety. In the above scenario, the robotic device could help with modulating the child's behavior and reduce the anxiety through free play or music. Thus, the participants suggested that the robot should be equipped with sounds of familiar animals, musical instruments and songs. The parents expressed the same concern about child's behaviour and agreed that the robot could contribute to reducing anxiety, even in the home, through using peaceful sounds.

> The robot could reduce child's anxiety levels, transmit calmness as well as confidence and thus avoid crises.

In addition, in the plenary discussion stakeholders acknowledged that the child's motivation can be increased through robot-assisted therapies, and that this can be used to help the child in other aspects, such as communication and activities of daily life. Also, the participants highlighted that with the robotic platform it is possible to stimulate the child using different communication channels, such as visual, auditory and tactile senses, proprioception and spatial exploration. Some robot prototypes specifically built for the participants in the generative activity are shown in Fig. 7.

While many positive aspects emerged in the focus group discussions, the participants also expressed some concerns. For example, both the parents and therapists agreed that a major concern is that in the medium to long-term, the child's behavior could be conditioned for the robot presence in the therapy, i.e., the child can find so much comfort in interacting with the robot that later on he or she will not want to interact with anyone else. Related to this one of the parents expressed:

> The robot therapy could limit my child's imagination and behavior; it could condition to the point of imitating and preferring the voice of the robot, getting used to the robot until he will not want to interact with other people.

Two more concerns emerged during the focus group discussions. The first one was related to whether robot-assisted therapy can generate stress, anxiety, and frustration for the child, due to abrupt movements of robot, the very loud or strange noises, or sudden mechanical failures. The second one, even though the focus group moderator reassured that a therapist would always facilitate the therapy, both parents and therapists expressed concerns about the reduction of human contact and the reduced amount of human emotional contact when using robot-assisted therapy. In other words, the use of robots may weaken human-care relationships (Fig. 7).

> I imagine that the worst thing that could happen after using a robot in therapies with my patients would be to lose the emotional bond that therapy normally generates between them and us. It is as if the humanity of the therapy was ignored.

The participants were also asked about the robot's role, for which we used context mapping and prioritization domain activities. When participants were asked about a "magic toolii" to help them during their work and care, they answered

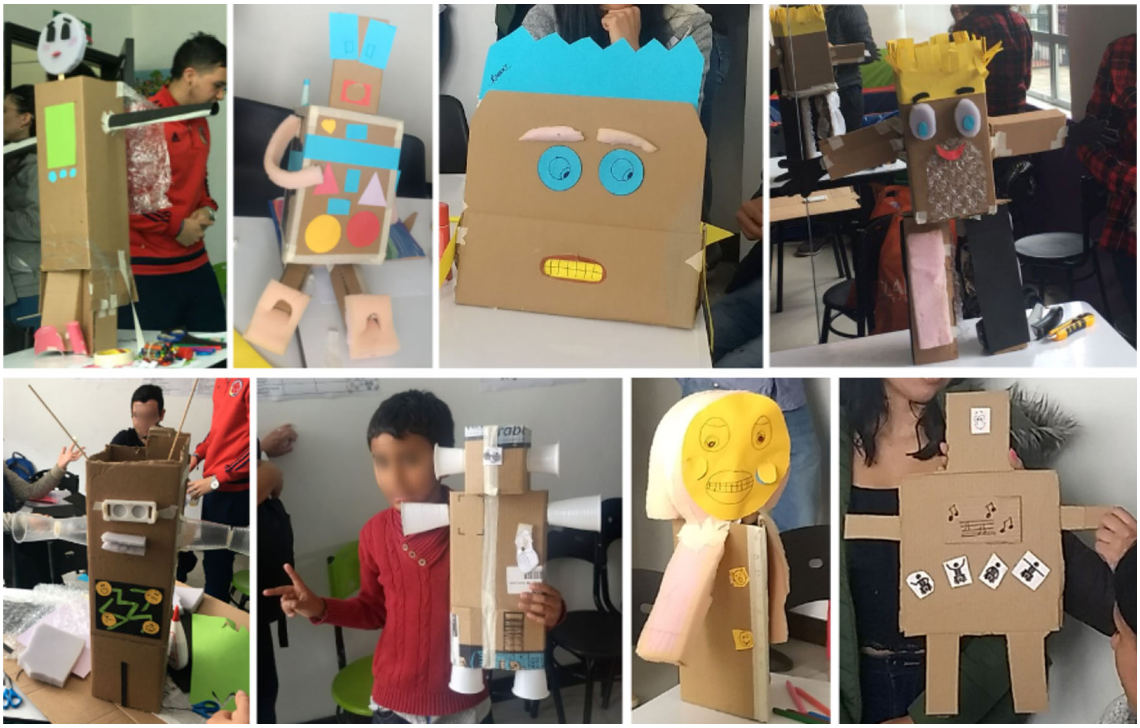

Fig. 7 Robots designed in the generative session of focus group

that they wanted a tool to interpret the child's thinking, emotions, and intentions. Thus, the central role for the robot would be like a "magic wandii" that can read the child's mind. These findings are also echoed in some of responses returned in the mailbox during the first phase of our work. However, when this topic was discussed in the plenary session, the participants agreed that the focus should be on improving the children's communication skills, and that this is to be preferred over interpreting the child's unexpressed beliefs and thoughts.

> What I would like the most is that my daughter, when she arrives at home after school, could express in some way how she did or how she felt. I think the robot could help her with that.

In addition, in all discussions about the robot's role, the participants imagined the robot in the role of mediator and facilitator, i.e., as a natural extension of the familiar intervention approach. The robot was never exclusively imagined or discussed as a therapist. Thus, when the focus group moderator led the discussion to this topic, the discussion quickly turned into the child's skills, in which the therapist could use the robot as a catalyst to help the child improve their social skills. In this sense, the parents and therapist identified that (1) verbal communication, (2) expressing of emotions and feelings and (3) functioning in daily life are the main skills that can be worked on in robot assisted therapy. This fact was consistent with the results of the prioritization domain activity. There, the parents and therapists expressed that strengthen skills relevant to dealing with daily challenges, such as personal care, eating, emotional well-being and verbal communication, are more important than other tasks.

5.3 Insights from Activities with CwASD

The activities developed with CwASD were challenging but enriching. On the one hand, all the children responded satisfactorily to all phases in part due to the use of material adapted to their needs. However, it is still necessary to make more efforts to encourage children to exhibit behaviors that describe their preferences in greater detail.

Despite the small size of the sample, the findings indicate that the children preferred the dinosaur Pleo. Perhaps unexpected, Nao and Kaspar were the worst-ranked robots. Trying to explain these findings is difficult, however, based on a qualitative analysis of the children's activities, the authors found that the children showed great enthusiasm when the therapist referred to animals they did not know, such as dragons and dinosaurs. The previous result also can be due to the baby-like features of Pleo, which would be consistent with the stakeholder' view, who affirmed that the robot should look like a baby, in order to allow the CwASD to identify the robot as a peer.

> The robot should have a friendly appearance, has to look kind and look like a child's peer.

Table 2 Summary of guidelines resulting from the participatory design process

Guidelines summary of robot design		
Physical requirements	Aesthetic features	Appearance of a fantastic animal or character (dragon, unicorns, sirens)
		Friendly appearance, look like a baby-featured character
		Neutral gender suitable to be customized
		It can have fantastic elements like tail, chins, crest, wings, etc.
	Body features	With active upper limbs and passive lower limbs (optional active lower limbs)
		Robot proportion around to 2–3 heads with a height between 40 and 50 cm
		Exaggerated facial features (mouth, two eyes, eyebrows, nose, two ears)
Mechanical and manufacturing features	Modularity	The robotic platform can have interchangeable and adjustable elements, such as nose, ears, hair, etc.
		The robotic platform can have accessories toolkit to customize the interaction, such as clothes, musical instruments, educational tools, and toys
		The robotic platform can have a soft-based structure and appropriate actuators to make a huggable robot
	Materials	Soft materials and different textures, such as silicone, textiles, plushes, leathers, and polymers
		Materials composed of primary colors and without prints or images
Technical features	Voice and sound	It can be equipped with gentle, natural voices (female and male) as well as familiar sounds of animals and musical instruments
		It would be suitable to playback music and video files
	Sensors and actuators	The actuator movements should be gradual, smooth and predictable; should be noiseless and should complement the soft structure
		It can be equipped with vision and touch sensors, microphone and an optional touch screen to produce different stimuli
Intervention implementation	Behaviours and actions	Head and upper limbs movement, look at, point towards, speech, facial expression, eye blinking, reward, grasp objects, hug, play sounds
		Not to use too many stimuli at the same time
	Suggested practices	The robotic platform can be used for different therapies and educational objectives: (i) occupational therapy; (ii) speech and language therapy; (iii) physical therapy; and (iv) psychology
		The intervention could be applied to decrease episodes of anxiety, to engage in communication activities, to feel confident in therapy, to increase motivation and to develop proprioception skill and spatial exploration
		It is crucial to establish a personalized robot-intervention plan to avoid conditioning by the robot's presence and improve the positive therapy effects
		Update the planning regularly

The PD process was designed not to impose limits on the ideation by the participants, from which the CASTOR distilled guidelines for the design and use of the robot. The authors believe that having lots of ideas and perspectives from different contributors and from different contexts improves the design and increases the positive impact of the design on the community. The main guidelines of the CASTOR project gathered during the first year are described in Table 2. In this table the community contributions were clustered into four groups, (1) physical requirements, (2) mechanical and manufacturing features, (3) technical features and, (4) intervention implementation. From a general perspective, the described guidelines are consistent with previous requirements regarding appearance and behavior reported by Huijnen et al. [16], and also provided by Cabibihan et al. [6] in their review. In addition, our generative approach confirms previous evidence described by Peca et al. [24] regarding the child's perception and appearance preferences, such as the robot should be visually engaging, have clear facial features and cartoon-like features. Nevertheless, the results presented in this work differ partially in some findings described by Peca et al. 2014. For example, in this study CwASD preferred Pleo instead of the Probo robot. On the other hand, Romibo was the second choice, and Kaspar and Nao obtained the lowest scores, contrary to what was reported Peca et al. [24]. Even though the sample in this work was smaller, the creative work activity confirms these findings. Also, the generative method directly inquired about the children's preferences through hands-on exercises, providing added value to the results. The authors believe that CwASD in our sample prefer robots that look like a fantastic character, with a preference for a neotenous appearance and with exaggerated features. In addition, a preference was expressed for a robot that is has an appearance sitting between a cartoon and a fantastic animal.

In addition, other important aspects regarding robot's specifications were established, such as, size and proportion, flexibility, modularity and Softness. Despite that the softness robot's features was considered as the main technical requirement since the conception of this research, in the validation phase the stakeholders confirmed the relevance of this feature by stating that they preferred soft structure and materials for the construction of the robot so that it could be huggable.

These requirements could be useful to address the different specialties of autism therapies and the natural diversity of CwASD.

6 Conclusion and Future Work

In this work, we reported a participatory design (PD) method to arrive at guidelines to develop a robotic-device suitable to be implemented for robot-assisted therapy for children with ASD. Additionally, a collaborative and inclusive community process specific to the Colombian context, is presented. The PD process itself provided an opportunity to learn from several community actors. Among them children, caregivers, parents and therapist, each with different cultural and social aspects, offering insights and scenarios traditionally not considered in robot design. This broad involvement enriched the project and offers an authentic and novel contribution to the research into SAR.

The current study has limitations that motivate future research. Despite the differences on socio-cultural conditions of the community that participated in this research, such as low economic resources, little schooling of parents, and difficult access to quality therapies, for the scope of this research we can't attribute a cultural impact on our findings directly, even if they exist. Thus, we propose as future work to analyze the cultural effects on design decisions. Also, we propose to collect more evidence through collaborative and inclusive activities to resolve open issues and to validate the preliminary findings of the first year project, as well as, validate the acceptance of the robot in a clinical scenario.

Acknowledgements This work was supported in part by the Royal Academy of Engineering, CASTOR Project: CompliAnt SofT Robotics (Grant IAPP1\100126), and the first author scholarship was supported in part by the Coordenãço de Aperfeiçoamento de Pessoal de Nivel Superior - Brasil (CAPES) - Finance Code 001.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest regarding the publication of this work.

References

1. Association, A.P.: DSM-5 diagnostic classification. In: Diagnostic and statistical manual of mental disorders. American psychiatric association (2013). https://doi.org/10.1176/appi.books.9780890425596.x00DiagnosticClassification
2. Baio J, Wiggins L, Christensen DL, Maenner MJ, Daniels J, Warren Z, Kurzius-Spencer M, Zahorodny W, Robinson C, Rosenberg CT, White T, Durkin MS, Imm P, Nikolaou L, Yeargin-Allsopp M, Lee LC, Harrington R, Lopez M, Fitzgerald RT, Hewitt A, Pettygrove S, Constantino JN, Vehorn A, Shenouda J, Hall-Lande J, Van K, Naarden Braun, Dowling NF (2018) Prevalence of autism spectrum disorder among children aged 8 years—autism and developmental disabilities monitoring network, 11 Sites, United States, 2014. MMWR Surveill Summ 67(6):1–23. https://doi.org/10.15585/mmwr.ss6706a1
3. Belpaeme T, Baxter PE, Read R, Wood R, Cuayáhuitl H, Kiefer B, Racioppa S, Kruijff-Korbayová I, Athanasopoulos G, Enescu V, Looije R, Neerincx M, Demiris Y, Ros-Espinoza R, Beck A, Cañamero L, Hiolle A, Lewis M, Baroni I, Nalin M, Cosi P, Paci G, Tesser F, Sommavilla G, Humbert R (2012) Multimodal child–robot interaction: building social bonds. J Hum Robot Interact 1(2):33–53. https://doi.org/10.5898/jhri.v1i2.62
4. Benton L, Vasalou A, Khaled R, Johnson H, Gooch D (2014) Diversity for design: a framework for involving neurodiverse children in the technology design process. In: Proceedings of the 32nd annual ACM conference on human factors in computing systems—CHI '14, pp 3747–3756. https://doi.org/10.1145/2556288.2557244
5. Bertel LB, Rasmussen DM, Christiansen E (2013) Robots for real: developing a participatory design framework for implementing educational robots in real-world learning environments. In: Lecture notes in computer science (including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics) 8118 LNCS (Part 2), pp 437–444. https://doi.org/10.1007/978-3-642-40480-1_29
6. Cabibihan JJ, Javed H, Ang M, Aljunied SM (2013) Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism. Int J Soc Robot 5(4):593–618. https://doi.org/10.1007/s12369-013-0202-2
7. Costescu CA, Vanderborght B, David DO (2014) Reversal learning task in children with autism spectrum disorder: a robot-based approach. J Autism Dev Disord 45(11):3715–3725. https://doi.org/10.1007/s10803-014-2319-z
8. David DO, Costescu CA, Matu S, Szentagotai A, Dobrean A (2018) Developing joint attention for children with autism in

robot-enhanced therapy. Int J Soc Robot. https://doi.org/10.1007/s12369-017-0457-0
9. Eggebrecht AT, Elison JT, Feczko E, Todorov A, Wolff JJ, Kandala S, Adams CM, Snyder AZ, Lewis JD, Estes AM, Zwaigenbaum L, Botteron KN, McKinstry RC, Constantino JN, Evans A, Hazlett HC, Dager S, Paterson SJ, Schultz RT, Styner MA, Gerig G, Das S, Kostopoulos P, Schlaggar BL, Petersen SE, Piven J, Pruett JR (2017) Joint attention and brain functional connectivity in infants and toddlers. Cereb Cortex 27(3):1709–1720. https://doi.org/10.1093/cercor/bhw403
10. Feil-Seifer D, Matarić MJ (2009) Toward socially assistive robotics for augmenting interventions for children with autism spectrum disorders. Springer Tracts Adv Robot 54:201–210. https://doi.org/10.1007/978-3-642-00196-3_24
11. Fletcher-Watson S, Adams J, Brook K, Charman T, Crane L, Cusack J, Leekam S, Milton D, Parr JR, Pellicano E (2018) Making the future together: shaping autism research through meaningful participation. Autism. https://doi.org/10.1177/1362361318786721
12. Frauenberger C, Good J, Keay-Bright W (2011) Designing technology for children with special needs: bridging perspectives through participatory design. CoDesign 7(1):1–28. https://doi.org/10.1080/15710882.2011.587013
13. Guha M, Druin A, Fails J (2014) Cooperative inquiry revisited: reflections of the past and guidelines for the future of intergenerational co-design. Int J Child-Comput Interact 1:14–23. https://doi.org/10.1016/j.ijcci.2012.08.003
14. Heerink M, Vanderborght B, Broekens J, Albó-Canals J (2016) New friends: social robots in therapy and education. Int J Soc Robot 8(4):443–444. https://doi.org/10.1007/s12369-016-0374-7
15. Hendriks N, Slegers K, Duysburgh P (2015) Codesign with people living with cognitive or sensory impairments: a case for method stories and uniqueness. CoDesign 11(1):70–82. https://doi.org/10.1080/15710882.2015.1020316
16. Huijnen CAGJ, Lexis MA, Jansens R, de Witte LP (2017) How to implement robots in interventions for children with autism? A co-creation study involving people with autism, parents and professionals. J Autism Dev Disord 47(10):3079–3096. https://doi.org/10.1007/s10803-017-3235-9
17. Huijnen CAGJ, Lexis MAS, Jansens R, de Witte LP (2016) Mapping robots to therapy and educational objectives for children with autism spectrum disorder. J Autism Dev Disord 46(6):2100–2114. https://doi.org/10.1007/s10803-016-2740-6
18. Huijnen CAGJ, Lexis MAS, de Witte LP (2016) Matching robot KASPAR to autism spectrum disorder (ASD) therapy and educational goals. Int J Soc Robot 8(4):445–455. https://doi.org/10.1007/s12369-016-0369-4
19. Kim E, Paul R, Shic F, Scassellati B (2012) Bridging the research gap: making HRI useful to individuals with autism. J Hum Robot Interact 1(1):26–54. https://doi.org/10.5898/JHRI.1.1.Kim
20. Kim ES, Berkovits LD, Bernier EP, Leyzberg D, Shic F, Paul R, Scassellati B (2013) Social robots as embedded reinforcers of social behavior in children with autism. J Autism Dev Disord 43(5):1038–1049. https://doi.org/10.1007/s10803-012-1645-2
21. Kumazaki H, Yoshikawa Y, Yoshimura Y, Ikeda T, Hasegawa C, Saito DN, Tomiyama S, An KM, Shimaya J, Ishiguro H, Matsumoto Y, Minabe Y, Kikuchi M (2018) The impact of robotic intervention on joint attention in children with autism spectrum disorders. Mol Autism 9(1):46. https://doi.org/10.1186/s13229-018-0230-8
22. Malinverni L, MoraGuiard J, Padillo V, Mairena M, Hervás A, Pares N (2014) Participatory design strategies to enhance the creative contribution of children with special needs. In: Proceedings of the 2014 conference on Interaction design and children—IDC '14, pp 85–94. https://doi.org/10.1145/2593968.2593981
23. Merter S, Hasirci D (2016) A participatory product design process with children with autism spectrum disorder. CoDesign 14(3):70–187. https://doi.org/10.1080/15710882.2016.1263669
24. Peca A, Simut R, Pintea S, Costescu C, Vanderborght B (2014) How do typically developing children and children with autism perceive different social robots? Comput Hum Behav 41:268–277. https://doi.org/10.1016/j.chb.2014.09.035
25. Robins B, Dautenhahn K (2014) Tactile interactions with a humanoid robot: novel play scenario implementations with children with autism. Int J Soc Robot 6(3):397–415. https://doi.org/10.1007/s12369-014-0228-0
26. A roadmap for U.S. robotics: from internet to robotics (2013) Georgia Institute of Technology. http://archive2.cra.org/ccc/files/docs/2013-Robotics-Roadmap
27. Saldien J, Goris K, Vanderborght B, Vanderfaeillie J, Lefeber D (2010) Expressing emotions with the social robot probo. Int J Soc Robot 2(4):377–389. https://doi.org/10.1007/s12369-010-0067-6
28. Scassellati B, Boccanfuso L, Huang CM, Mademtzi M, Qin M, Salomons N, Ventola P, Shic F (2018) Improving social skills in children with ASD using a long-term, in-home social robot. Sci Robot 3(21):eaat7544
29. Scassellati B, Admoni H, Matarić MJ (2012) Robots for use in autism research. Ann Rev Biomed Eng 14(1):275–294. https://doi.org/10.1146/annurev-bioeng-071811-150036
30. Shick A (2013) Romibo robot project. In: ACM SIGGRAPH 2013 studio talks on—SIGGRAPH '13, ACM Press, New York, pp 1–1. https://doi.org/10.1145/2503673.2503689
31. Vallès-Peris N, Angulo C, Domènech M (2018) Children's imaginaries of human–robot interaction in healthcare. Int J Environ Res Publ Health 15(5):970. https://doi.org/10.3390/ijerph15050970
32. Yun SS, Choi J, Park SK, Bong GY, Yoo H (2017) Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system. Autism Res 10(7):1306–1323. https://doi.org/10.1002/aur.1778
33. Zubrycki I, Kolesinski M, Granosik G (2016) A participatory design for enhancing the work environment of therapists of disabled children. In: 25th IEEE international symposium on robot and human interactive communication, RO-MAN, New York, pp 781–786. https://doi.org/10.1109/ROMAN.2016.7745208

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.